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FEMA 209:410056

FLOOD INSURANCE STUDY

ORIGINAL

CITY OF BEND, OREGON
DESCHUTES COUNTY

SEPTEMBER 4, 1987

Federal Emergency Management Agency

COMMUNITY NUMBER - 410056

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NOTICE TO
FLOOD INSURANCE STUDY USERS

Communities participating in the National Flood Insurance Program have established repositories of flood hazard data for flood plain management and flood insurance purposes. This Flood Insurance Study may not contain all data available within the repository. It is advisable to contact the community repository for any additional data.

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1.0 INTRODUCTION

1.1 Purpose of Study

This Flood Insurance Study investigates the existence and severity of flood hazards in the City of Bend, Deschutes County, Oregon, and aids in the administration of the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973. This study has developed flood risk data for various areas of the community that will be used to establish actuarial flood insurance rates and assist the community in its efforts to promote sound flood plain management. Minimum flood plain management requirements for participation in the National Flood Insurance Program (NFIP) are set forth in the Code of Federal Regulations at 44 CFR, 60.3.

In some states or communities, flood plain management criteria or regulations may exist that are more restrictive or comprehensive than the minimum Federal requirements. In such cases, the more restrictive criteria take precedence and the State (or other jurisdictional agency) will be able to explain them.

1.2 Authority and Acknowledgments

The sources of authority for this Flood Insurance Study are the National Flood Insurance Act of 1968 and the Flood Disaster Protection Act of 1973.

The hydrologic and hydraulic analyses for this study were performed by U.S. Army Corps of Engineers (COE), Portland District, for the Federal Emergency Management Agency (FEMA), under Inter-Agency Agreement No. IAA-EMW-E-1153, Project Order No. 1, Amendment No. 29. This study was completed in October 1985.

1.3 Coordination

The initial coordination meeting was held on July 11, 1983, in the City of Bend. The meeting was attended by representatives from FEMA, COE, and the city. The purpose of the meeting was to inform the city of its status in the NFIP, gather all available pertinent data on flooding in the community, and reach an agreement on areas to be studied.

The U.S. Bureau of Reclamation, U.S. Geological Survey (USGS), U.S. Soil Conservation Service, Oregon Water Resources Department, Oregon Department of Transportation, and the State Director of the Bureau of Land Management were contacted for available flood information and pertinent flood data.

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On September 29, 1986, the results of the study were discussed at the final community coordination meeting, which was attended by representatives of FEMA, the study contractor, and the community. All significant problems raised at that meeting have been addressed in this study.

2.0 AREA STUDIED

2.1 Scope of Study

This Flood Insurance Study covers the incorporated areas of the City of Bend, Deschutes County, Oregon. The area of study is shown on the Vicinity Map (Figure 1).

The study area includes an 8.2-mile section of the Deschutes River, beginning approximately 162 miles upstream of its confluence with the Columbia River and ending at the southern corporate limits of Bend. Approximately 7.5 miles of the Deschutes River within Bend have been studied by detailed methods, and the remainder by approximate methods.

The areas studied by detailed methods were selected with priority given to all known flood hazard areas and areas of projected development or proposed construction through October 1990.

Approximate analyses were used to study those areas having a low development potential or minimal flood hazards.

2.2 Community Description

Bend, located in central Deschutes County, in central Oregon, is on the banks of the Deschutes River. The city was originally named "Farewell Bend" and was founded by A.M. Drake in 1900. The "Farewell" was dropped by the postal authorities, and Bend was incorporated in 1904. Railroads came in 1911, and lumbermills were established by 1915 (Reference 1).

The county seat of Deschutes County, Bend is a trade center for central Oregon, and its income is derived mostly from wood products, agriculture, and tourism (Reference 1).

The population of Bend increased approximately 51 percent between 1950 and 1980 (populations of 11,409 and 17,263, respectively), and the 1984 population estimate was about 18,300 (Reference 2).

The climate of Bend is characterized by cold winters and warm, dry summers. The average annual precipitation is 11.5 inches, and the average temperatures range from 63°F in July to 31°F in January (Reference 2).

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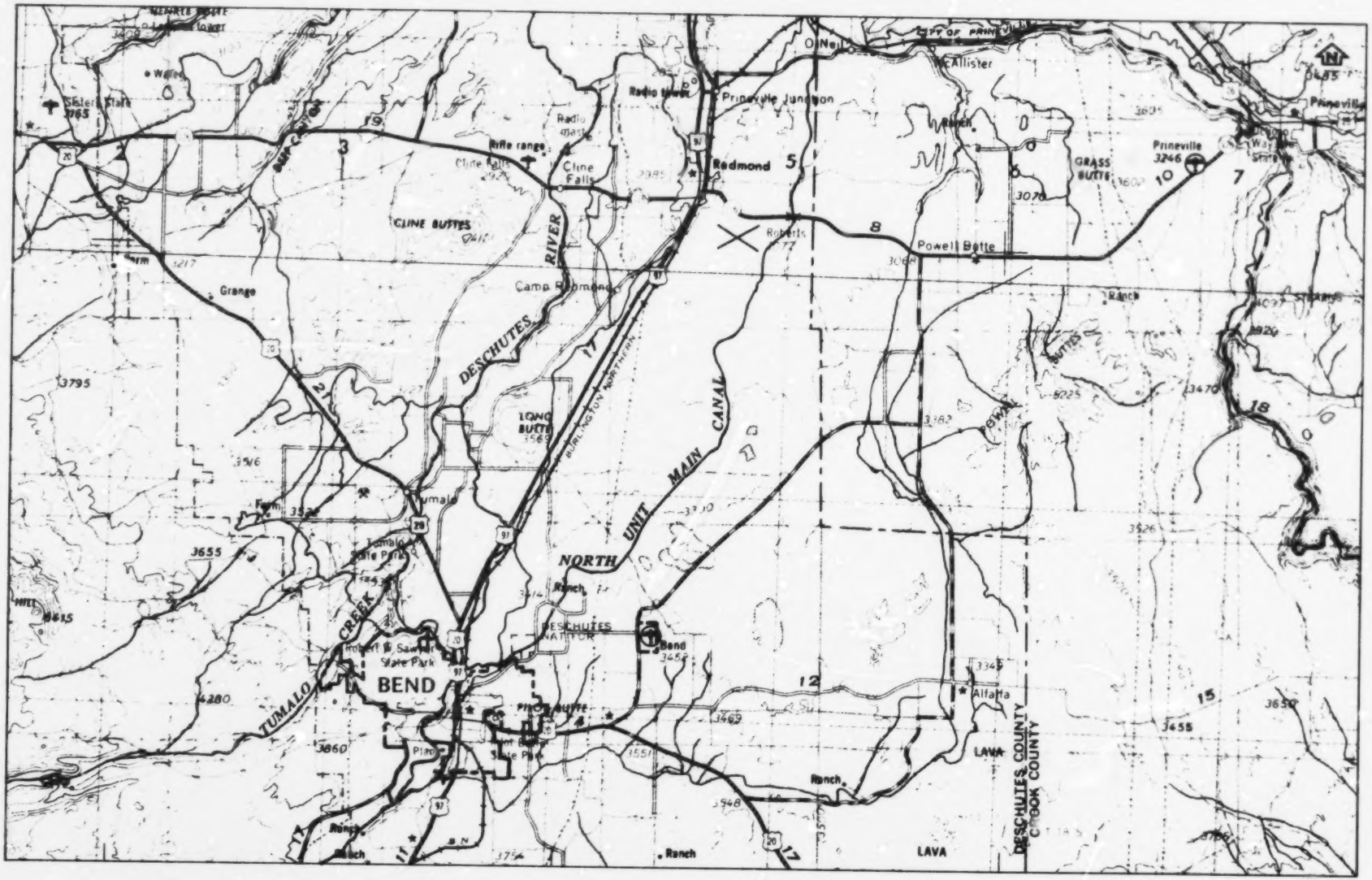

FIGURE 1

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF BEND, OR
(DESCHUTES CO.)

APPROXIMATE SCALE

4 0 4 8 12 MILES

VICINITY MAP

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The Deschutes River Basin upstream of Bend contains pumice sand underlain by highly permeable basalt. These very porous soils of volcanic origin contain a large amount of subsurface storage. This storage has a dampening effect on floodflows, and the Deschutes River in the vicinity of Bend has some of the lowest discharge rates per square mile of any comparably sized basin in the State (Reference 3).

The native vegetation in the vicinity of Bend is mostly grass, brush, and small trees or shrubs, with some pine trees on the higher hills away from the river.

2.3 Principal Flood Problems

The annual flood season extends from November through June, with a majority of the larger floods occurring in November and December. Some high waters result from snowmelt that occurs in late spring. Floods are possible whenever the rainfall is abnormally intense or prolonged, especially if the rain falls on an existing snowpack in the surrounding mountains.

The record flood on the Deschutes River below the Little Deschutes River confluence occurred on November 27, 1909, with a discharge at the Benham Falls Stream gage of 5,000 cubic feet per second (cfs) and at the gage below Bend of 4,820 cfs. A natural frequency curve has not been developed for the Deschutes River main stem because of the operation of Wickiup Dam, which began in 1922; therefore, no frequency has been assigned to this preregulation flood.

The most significant discharge in the past 15 years downstream of Bend, Oregon, was 1,820 cfs below the Bend gage station. It occurred on March 20, 1972, and had a recurrence interval of approximately 8 years.

The most significant discharge in the past 15 years upstream of the North Unit Dam occurred on July 23-24, 1976. The release from Wickiup Reservoir was 2,140 cfs, and the Benham Falls gage recorded 2,780 cfs. The Wickiup release was approximately a 7-year frequency discharge, and the Benham Falls discharge was approximately a 3-year frequency discharge.

In December 1983, Bend experienced flooding due to blockage of the channel by ice. Several consecutive days of freezing temperatures combined with high flows to form frazil ice and ice jams. Frazil ice is generated in turbulent open-water areas of a river having velocities in excess of 2.0 to 2.5 feet per second, when the water temperature is a few hundredths of a degree below freezing. Prolonged cold spells of below-zero temperatures, low relative humidity, and high wind velocity can supercool water to below freezing. Frazil ice consists of small crystals of ice that are adhesive and readily attach to objects in the channel, such as rocks and logs. Frazil

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ice that does not become attached to objects flocculates and rises to the surface. The flocs freeze together and form clumps of slush ice, which then form ice pans. These ice pans grow large enough to be considered icefloes (Reference 4).

At Bend, two ponds are formed on the Deschutes River: Mirror Pond, formed by the Pacific Power and Light (PP&L) Dam, and an upstream pond, formed by a low-level dam at the Colorado Avenue bridge. The upstream pond was used as a log storage area until 1973. Between the two ponds, there is a 0.5-mile section of river channel that has a much narrower cross section than the ponds. The unattached frazil ice generated in upstream river reaches congeals to form surface icefloes by the time it gets to the log pond. These floes drift to the PP&L Dam, where they become trapped. They subsequently begin to freeze together to form an ice cover that grows upstream as icefloes accumulate. When the ice sheet gets to that portion of the river between the ponds, icefloes begin to be forced under the ice sheet because of the greater velocities that exist in that narrow portion of channel. These floes thus become lodged under the surface ice, causing damming. Velocities in this river segment may be swift enough to generate frazil ice, which could also adhere to the surface ice, compounding the problem (Reference 4).

Local officials report that there were no ice-jam flooding problems prior to 1973, when logs were stored in the upstream pond. Apparently, the stored logs acted as an icefloe barricade, and the ice cover formed from that point upstream. Presumably, ice jams formed upstream of the log pond prior to 1973, but areas that were overtopped were unimproved and suffered little damage (Reference 4).

Figures 2 and 3 show estimated 100-year flood elevations for the Deschutes River.

Figure 2. Portland Avenue Bridge, 100-Year Flood Elevation

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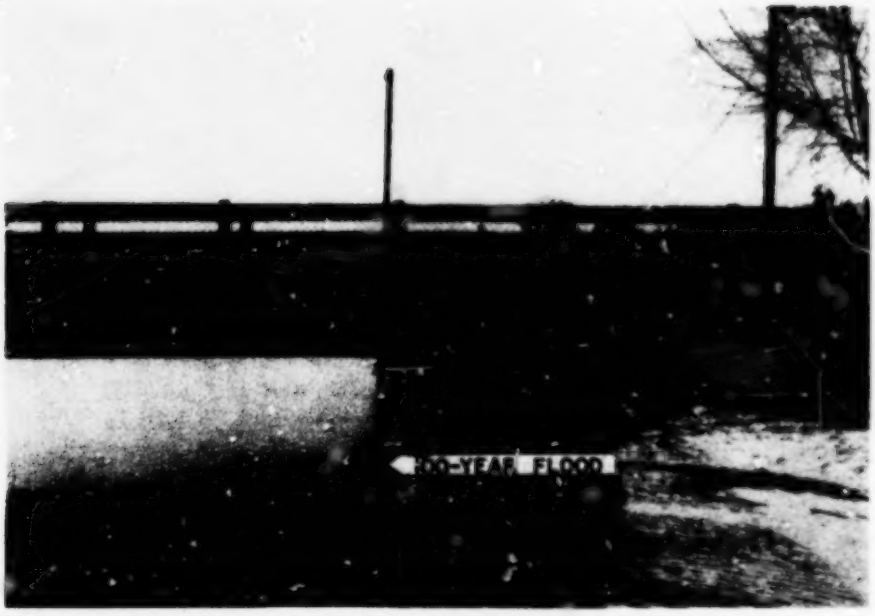

Figure 3. Drake Park Foot Bridge, 100-Year Flood Elevation

2.4 Flood Protection Measures

There are three water storage reservoirs in the Upper Deschutes River basin (Crane Prairie, Wickiup, and Crescent Lake) that are operated by the U.S. Bureau of Reclamation. Although no flood-control storage is authorized for these reservoirs, the large amount of irrigation storage available does, in fact, reduce winter and spring flows downstream.

There are a series of irrigation diversion structures located on the Deschutes River. The structures are used to divert some of the flow for irrigation purposes. Although the total flow is reduced, they are not considered to be recognized flood-control devices.

In November 1984, the City installed an ice boom just upstream of the Colorado Avenue bridge to intercept icefloes above Mirror Pond and prevent ice-jam flooding in residential areas of the city.

The COE is preparing a detailed report to determine the feasibility of constructing an icefloe barricade. The COE is continuing efforts on the study at the request of the City because early results indicate a stronger ice boom would be needed farther upstream than the city's, at a location more favorable to intercepting frazil ice.

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No other structural flood protection measures exist or are proposed for Bend. Nonstructural measures, however, are being used to aid in the prevention of future flood damage. These are in the form of an ordinance passed by the City Council on March 2, 1983, authorizing the City to control future development or redevelopment within the 100-year flood plain. The City requires building permits for construction and reviews those permits to ensure that sites are reasonably safe from flooding.

3.0 ENGINEERING METHODS

For the flooding sources studied in detail in the community, standard hydrologic and hydraulic study methods were used to determine the flood hazard data required for this study. Flood events of a magnitude which are expected to be equaled or exceeded once on the average during any 10-, 50-, 100-, or 500-year period (recurrence interval) have been selected as having special significance for flood plain management and for flood insurance rates. These events, commonly termed the 10-, 50-, 100-, and 500-year floods, have a 10, 2, 1, and 0.2 percent chance, respectively, of being equaled or exceeded during any year. Although the recurrence interval represents the long-term average period between floods of a specific magnitude, rare floods could occur at short intervals or even within the same year. The risk of experiencing a rare flood increases when periods greater than 1 year are considered. For example, the risk of having a flood which equals or exceeds the 100-year flood (1 percent chance of annual exceedence) in any 50-year period is approximately 40 percent (4 in 10), and, for any 90-year period, the risk increases to approximately 60 percent (6 in 10). The analyses reported herein reflect flooding potentials based on conditions existing in the community at the time of completion of this study. Maps and flood elevations will be amended periodically to reflect future changes.

3.1 Hydrologic Analyses

Hydrologic analyses were carried out to establish the peak discharge-frequency relationships for each flooding source studied in detail affecting the community.

The Upper Deschutes River subbasin, including all of the Deschutes River watershed above the stream gage below Bend, contains 1,899 square miles, which is about 18 percent of the total area of the Deschutes Basin.

The subbasin is bounded on the west by the Cascade Range; on the south by the divide between the Deschutes and Klamath Basins; on the east by the Walker Rim, Crater Buttes, and Paulina Mountains; and on the north by an arbitrary divide that extends from the Paulina Mountains through Bend to the Three Sisters in the Cascades (Reference 3).

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In general, the Deschutes River is subject to high water caused by spring snowmelt. In only two years, 1944 and 1964, out of the 44 years since the river has been regulated by all three storage projects (Wickiup, Crane Prairie, and Crescent Lake), was the peak discharge caused primarily by rainfall.

Because there were only two significant rain-on-snow events, it was determined that a reliable rain-on-snow, discharge-frequency curve could not be derived.

The three reservoirs regulate an area of approximately 540 square miles, or 28 percent of the subbasin (Reference 5). For this reason and because of numerous irrigation withdrawals, it was determined that a frequency curve based on observed data best represents existing conditions. U.S. Water Resources Council guidelines were used with a generalized skew of -0.36 (Reference 6). From analysis of the total record since 1907, the December 1964 event is the largest in 68 years.

For the reach of the Deschutes River between the North Unit Dam and approximately 5.4 miles upstream, Benham Falls discharges were used. Three major irrigation diversions are located at the North Unit Dam. Therefore, the discharges for the 2.8-mile reach below the dam were from the Deschutes River USGS stream gage below the City of Bend.

Peak discharge-drainage area relationships for the Deschutes River in the vicinity of Bend are shown in Table 1.

3.2 Hydraulic Analyses

Analyses of the hydraulic characteristics of flooding from the sources studied were carried out to provide estimates of the elevations of floods of the selected recurrence intervals.

The hydraulic analyses were performed using the COE HEC-2 step-backwater computer program (Reference 7). Cross sections for the Deschutes River were developed from field surveys and orthophoto topographic maps developed from July 1984 aerial photography (Reference 8). The model was calibrated using engineering judgment and information about past flooding events from local officials and residents along the Deschutes River.

Bridges and dams were field surveyed where no as-built drawings existed. Where as-built drawings were available, their elevation datum was checked by field survey.

The river was divided into four reaches separated by three dams. To estimate the backwater effects for two of the dams, the spillways were modeled as cross sections with a steep starting slope. The HEC-2 program forced the water surface to critical depth. The

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Table 1. Summary of Discharges

Flooding Source and Location	Drainage Area (Square Miles)	Peak Discharges (cfs) 10-Year	50-Year	100-Year	500-Year
Deschutes River					
Upstream of North Unit Dam	1,835	3,070	3,320	3,400	3,560
Downstream of North Unit Dam	1,895	1,920	2,460	2,685	3,200

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third dam was modeled with a known water-surface elevation determined from manual weir-flow calculations.

The starting water-surface elevations for the channel reach downstream of the last dam were determined by specifying the starting slope. The starting slope was determined from a combination of field survey notes and topographical maps. Approximate water-surface elevations were obtained from the field survey notes.

Locations of selected cross sections used in the hydraulic analyses are shown on the Flood Profiles (Exhibit 1). For stream segments for which a floodway was computed (Section 4.2), selected cross section locations are also shown on the Flood Insurance Rate Map (Exhibit 2).

Roughness factors (Manning's "n") used in the hydraulic computations were chosen by engineering judgment and based on field observations of the stream and flood plain areas. The roughness value used for the main channel of the Deschutes River was 0.043; the flood plain roughness values ranged from 0.10 to 0.12 for all floods.

The hydraulic analyses for this study were based on unobstructed flow. The flood elevations shown on the profiles are thus considered valid only if hydraulic structures remain unobstructed, operate properly, and do not fail.

All elevations are referenced to the National Geodetic Vertical Datum of 1929 (NGVD). Elevation reference marks used in this study are shown on the maps; the descriptions of the marks are presented in Elevation Reference Marks (Exhibit 3).

4.0 FLOOD PLAIN MANAGEMENT APPLICATIONS

The NFIP encourages State and local governments to adopt sound flood plain management programs. Therefore, each Flood Insurance Study provides 100-year flood elevations and delineations of the 100- and 500-year flood plain boundaries and 100-year floodway to assist communities in developing flood plain management measures.

4.1 Flood Boundaries

To provide a national standard without regional discrimination, the 1 percent annual chance (100-year) flood has been adopted by FEMA as the base flood for flood plain management purposes. The 0.2 percent annual chance (500-year) flood is employed to indicate additional areas of flood risk in the community. For each stream studied in detail, the 100- and 500-year flood plain boundaries have been delineated using the flood elevations determined at each cross section. Between cross sections, the boundaries were inter-

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polated using topographic maps at a scale of 1:4,800, with a contour interval of 4 feet (Reference 8).

The 100- and 500-year flood plain boundaries are shown on the Flood Boundary and Floodway Map (Exhibit 2). On this map, the 100-year flood plain boundary corresponds to the boundary of the areas of special flood hazards (Zones A and AE), and the 500-year flood plain boundary corresponds to the boundary of areas of moderate flood hazards. In cases where the 100- and 500-year flood plain boundaries are close together, only the 100-year flood plain boundary has been shown. Small areas within the flood plain boundaries may lie above the flood elevations but cannot be shown due to limitations of the map scale and/or lack of detailed topographic data.

For the portion of the stream studied by approximate methods, only the 100-year flood plain boundary is shown on the Flood Insurance Rate Map (Exhibit 2).

4.2 Floodways

Encroachment on flood plains, such as structures and fill, reduces flood-carrying capacity, increases flood heights and velocities, and increases flood hazards in areas beyond the encroachment itself. One aspect of flood plain management involves balancing the economic gain from flood plain development against the resulting increase in flood hazard. For purposes of the NFIP, a floodway is used as a tool to assist local communities in this aspect of flood plain management. Under this concept, the area of the 100-year flood plain is divided into a floodway and a floodway fringe. The floodway is the channel of a stream, plus any adjacent flood plain areas, that must be kept free of encroachment so that the 100-year flood can be carried without substantial increases in flood heights. Minimum Federal standards limit such increases to 1.0 foot, provided that hazardous velocities are not produced. The floodways in this study are presented to local agencies as minimum standards that can be adopted directly or that can be used as a basis for additional floodway studies.

The floodways presented in this study were computed for certain stream segments on the basis of equal conveyance reduction from each side of the flood plain. Floodway widths were computed at cross sections. Between cross sections, the floodway boundaries were interpolated. The results of the floodway computations are tabulated for selected cross sections (Table 2). The computed floodways are shown on the Flood Insurance Rate Map (Exhibit 2). In cases where the floodway and 100-year flood plain boundaries are either close together or collinear, only the floodway boundary is shown.

The area between the floodway and 100-year flood plain boundaries is termed the floodway fringe. The floodway fringe encompasses

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FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Deschutes River								
A	2,060	45/30[2]	227	11.8	3,377.8	3,377.8	3,377.8	0.0
B	11,715	120/30[2]	810	3.3	3,508.1	3,508.1	3,508.2	0.1
C	12,605	52/20[2]	237	11.3	3,508.7	3,508.7	3,508.8	0.1
D	13,415	50	294	9.1	3,518.3	3,518.3	3,518.7	0.4
E	13,965	58	535	5.0	3,521.2	3,521.2	3,521.7	0.5
F	14,705	45	214	12.6	3,524.5	3,524.5	3,524.5	0.0
G	15,125	293	2,802	1.2	3,560.4	3,560.4	3,560.5	0.1
H	16,155	140	1,656	2.1	3,560.5	3,560.5	3,560.6	0.1
I	17,530	155	1,287	2.6	3,560.7	3,560.7	3,560.9	0.2
J	18,510	150	1,044	3.3	3,561.1	3,561.1	3,561.3	0.2
K	19,090	88	314	10.8	3,564.4	3,564.4	3,564.4	0.0
L	19,680	152	602	5.7	3,570.5	3,570.5	3,570.5	0.0
M	19,785	202	1,978	1.7	3,578.9	3,578.9	3,568.9	0.0
N	20,315	185	2,056	1.7	3,579.0	3,579.0	3,579.0	0.0
O	22,252	367	2,894	1.2	3,594.7	3,594.7	3,594.7	0.0
P	23,027	121	1,099	3.1	3,594.8	3,594.8	3,594.8	0.0
Q	23,727	234	1,984	1.7	3,595.1	3,595.1	3,595.1	0.0
R	24,566	321	2,335	1.5	3,595.3	3,595.3	3,595.3	0.0
S	25,238	471	2,527	1.4	3,595.4	3,595.4	3,595.4	0.0
T	25,836	107	1,091	3.1	3,595.5	3,595.5	3,595.5	0.0
U	26,416	184	958	3.6	3,595.9	3,595.9	3,595.9	0.0
V	27,434	131	1,412	2.4	3,596.8	3,596.8	3,596.8	0.0
W	28,144	246	1,421	2.4	3,597.0	3,597.0	3,597.0	0.0
X	29,082	452	2,424	1.4	3,604.8	3,604.8	3,604.8	0.0

[1]Feet Above Limit of Detailed Study [2]Width/Width Within Corporate Limits

TABLE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF BEND, OREGON
(DESCHUTES COUNTY)

FLOODWAY DATA

DESCHUTES RIVER

FLOODING SOURCE		FLOODWAY			BASE FLOOD WATER SURFACE ELEVATION			
CROSS SECTION	DISTANCE[1]	WIDTH (FEET)	SECTION AREA (SQUARE FEET)	MEAN VELOCITY (FEET PER SECOND)	REGULATORY	WITHOUT FLOODWAY	WITH FLOODWAY	INCREASE
					(FEET NGVD)			
Deschutes River (Continued)								
Y	29,872	365/240[2]	1,924	1.8	3,604.9	3,604.9	3,604.9	0.0
Z	31,022	138/100[2]	1,118	3.0	3,605.3	3,605.3	3,605.3	0.0
AA	31,632	106/80[2]	824	4.1	3,605.6	3,605.6	3,605.6	0.0
AB	32,337	355/200[2]	2,291	1.5	3,606.1	3,606.1	3,606.1	0.0
AC	33,147	289/130[2]	1,688	2.0	3,606.2	3,606.2	3,606.3	0.1
AD	34,517	254/130[2]	1,713	2.0	3,607.0	3,607.0	3,607.0	0.0
AE	35,327	218/170[2]	1,791	1.9	3,607.2	3,607.2	3,607.2	0.0
AF	36,327	194/190[2]	1,202	7.8	3,607.4	3,607.4	3,607.5	0.1
AG	37,637	180/140[2]	1,109	3.1	3,608.3	3,608.3	3,608.3	0.0
AH	38,347	97/70[2]	327	10.4	3,610.0	3,610.0	3,610.0	0.0
AI	39,137	111/60[2]	544	6.3	3,617.0	3,617.0	3,617.0	0.0

[1]Feet Above Limit of Detailed Study

[2]Width/Width Within Corporate Limits

TABLE 2

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF BEND, OREGON

(DESCHUTES COUNTY)

FLOODWAY DATA

DESCHUTES RIVER

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the portion of the flood plain that could be completely obstructed without increasing the water-surface elevation of the 100-year flood by more than 1.0 foot at any point. Typical relationships between the floodway and the floodway fringe and their significance to flood plain development are shown in Figure 4.

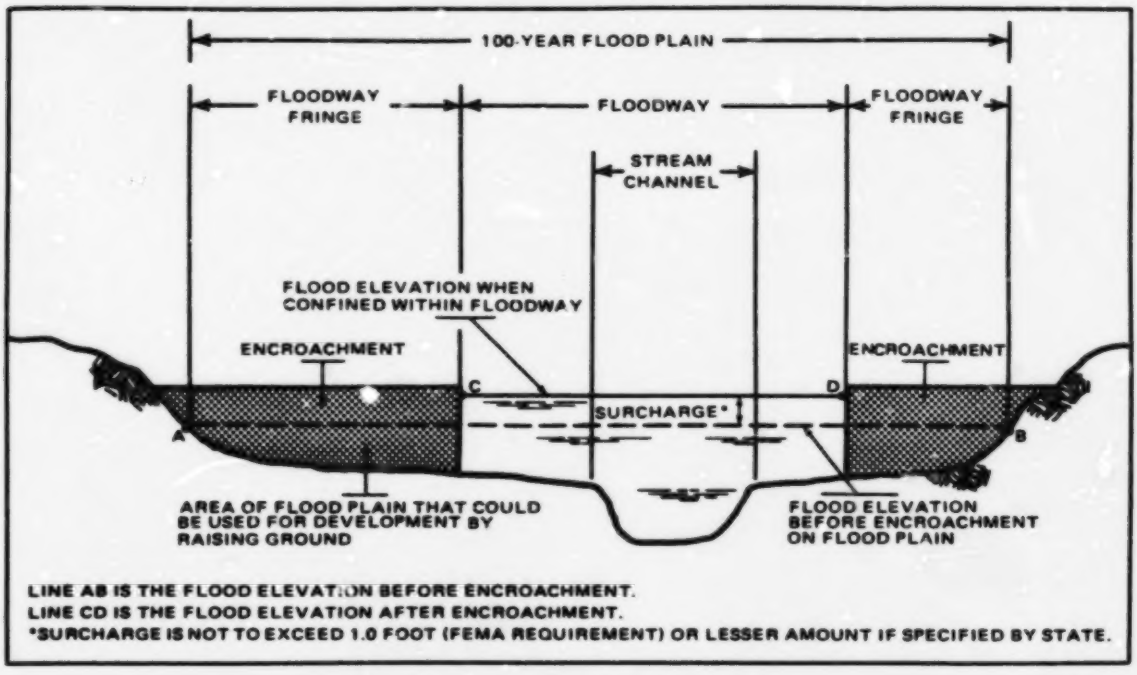
100-YEAR FLOOD PLAIN
FLOODWAY FRINGE
FLOODWAY
FLOODWAY FRINGE
STREAM CHANNEL
FLOOD ELEVATION WHEN CONFINED WITHIN FLOODWAY
ENCROACHMENT
ENCROACHMENT
C
D
SURCHARGE*
A
B
AREA OF FLOOD PLAIN THAT COULD BE USED FOR DEVELOPMENT BY RAISING GROUND
FLOOD ELEVATION BEFORE ENCROACHMENT ON FLOOD PLAIN
LINE AB IS THE FLOOD ELEVATION BEFORE ENCROACHMENT.
LINE CD IS THE FLOOD ELEVATION AFTER ENCROACHMENT.
*SURCHARGE IS NOT TO EXCEED 1.0 FOOT (FEMA REQUIREMENT) OR LESSER AMOUNT IF SPECIFIED BY STATE.

Figure 4. Floodway Schematic

5.0 INSURANCE APPLICATION

For flood insurance rating purposes, flood insurance zone designations are assigned to a community based on the results of the engineering analyses. These zones are as follows:

Zone A

Zone A is the flood insurance rate zone that corresponds to the 100-year flood plains that are determined in the Flood Insurance Study by approximate methods. Because detailed hydraulic analyses are not performed for such areas, no base flood elevations or depths are shown within this zone.

Zone AE

Zone AE is the flood insurance rate zone that corresponds to the 100-year flood plains that are determined in the Flood Insurance Study by detailed methods. Whole-foot base flood elevations derived

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from the detailed hydraulic analyses are shown at selected intervals within this zone.

Zone X

Zone X is the flood insurance rate zone that corresponds to areas outside the 500-year flood plain, areas within the 500-year flood plain, areas of 100-year flooding where average depths are less than 1 foot, areas of 100-year flooding where the contributing drainage area is less than 1 square mile, and areas protected from the 100-year flood by levees. No base flood elevations or depths are shown within this zone.

6.0 FLOOD INSURANCE RATE MAP

The Flood Insurance Rate Map is designed for flood insurance and flood plain management applications.

For flood insurance applications, the map designates flood insurance rate zones as described in Section 5.0 and, in the 100-year flood plains that were studied by detailed methods, shows selected whole-foot base flood elevations or average depths. Insurance agents use the zones and base flood elevations in conjunction with information on structures and their contents to assign premium rates for flood insurance policies.

For flood plain management applications, the map shows by tints, screens, and symbols, the 100- and 500-year flood plains, the floodways, and the locations of selected cross sections used in the hydraulic analyses and floodway computations.

7.0 OTHER STUDIES

A Flood Insurance Study is in progress for the unincorporated areas of Deschutes County (Reference 9), including the area surrounding Bend. The results of this study and those of the Deschutes County Flood Insurance Study will be in agreement.

8.0 LOCATION OF DATA

Information concerning the pertinent data used in the preparation of this study can be obtained by contacting the Natural and Technological Hazards Division, FEMA, Federal Regional Center, 130 228th Street, SW., Bothell, Washington 98021-9796.

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9.0 BIBLIOGRAPHY AND REFERENCES

1. Bend Visitor and Convention Bureau, Points of Interest Brochure, 1982-83, Bend, Oregon, 1983

2. Barbara Roberts, Secretary of State, Oregon Blue Book, 1985-86, March 1985

3. State Water Resources Board, Deschutes River Basin, January 1961

4. U.S. Department of the Army, Corps of Engineers, Portland District, Memo to Files, "Deschutes River at Bend, Oregon, Ice-Jam Flooding," October 5, 1984

5. Columbia Basin Inter-Agency Committee, River Mile Index, Deschutes River, June 1963

6. U.S. Water Resources Council, "Guidelines for Determining Flood Flow Frequency," Bulletin 17, March 1976

7. U.S. Department of the Army, Corps of Engineers, Hydrologic Engineering Center, HEC-2 Water-Surface Profiles, Generalized Computer Program, Davis, California, November 1976, updated May 1982

8. U.S. Department of the Army, Corps of Engineers, Portland District, Deschutes River Work Map, Scale 1:4,800, Contour Interval 4 feet, July 27, 1984

9. Federal Emergency Management Agency, Flood Insurance Study, Deschutes County, Oregon (Unincorporated Areas), unpublished

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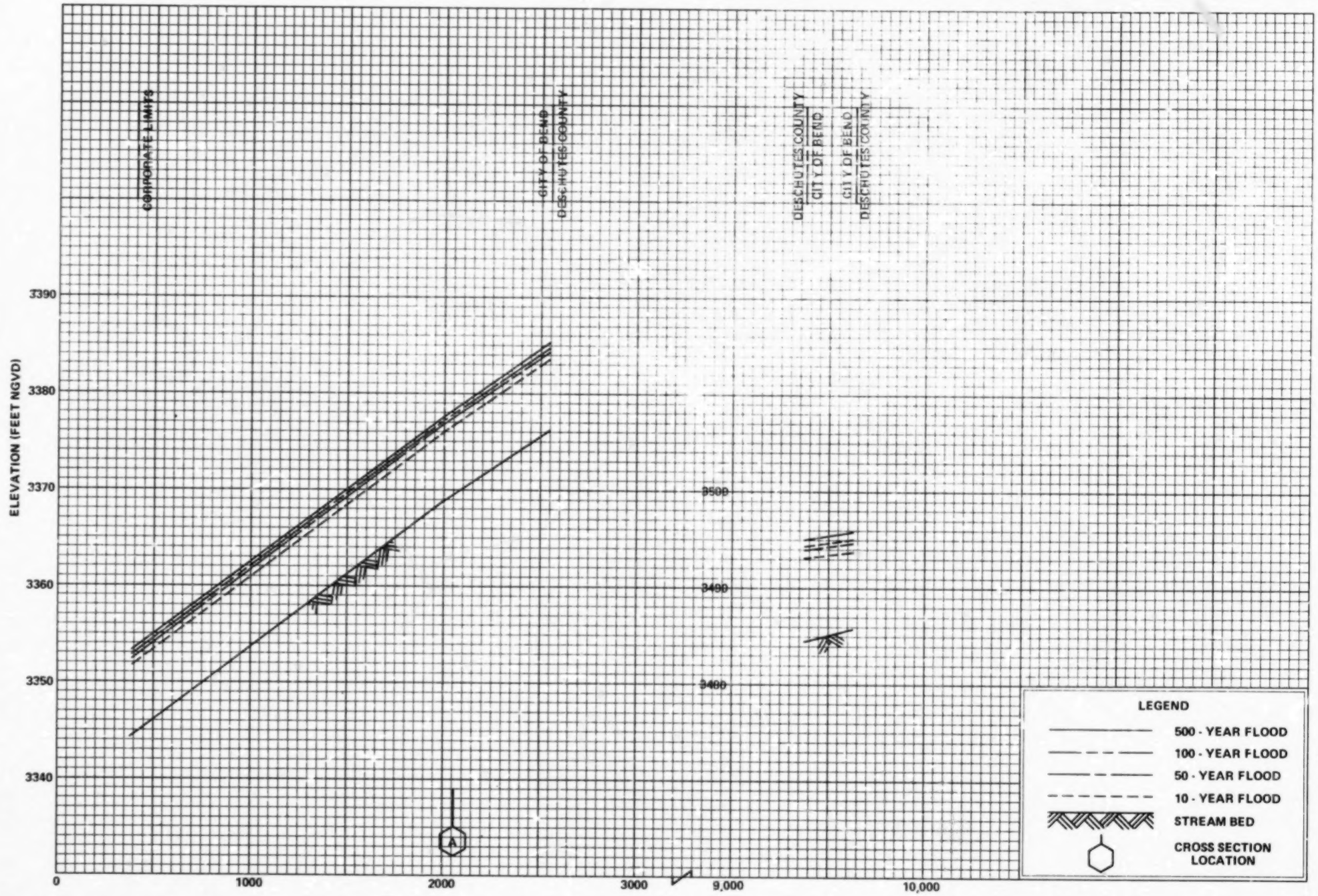

FLOOD PROFILES

DESCHUTES RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF BEND, OR
(DESCHUTES CO.)

01P

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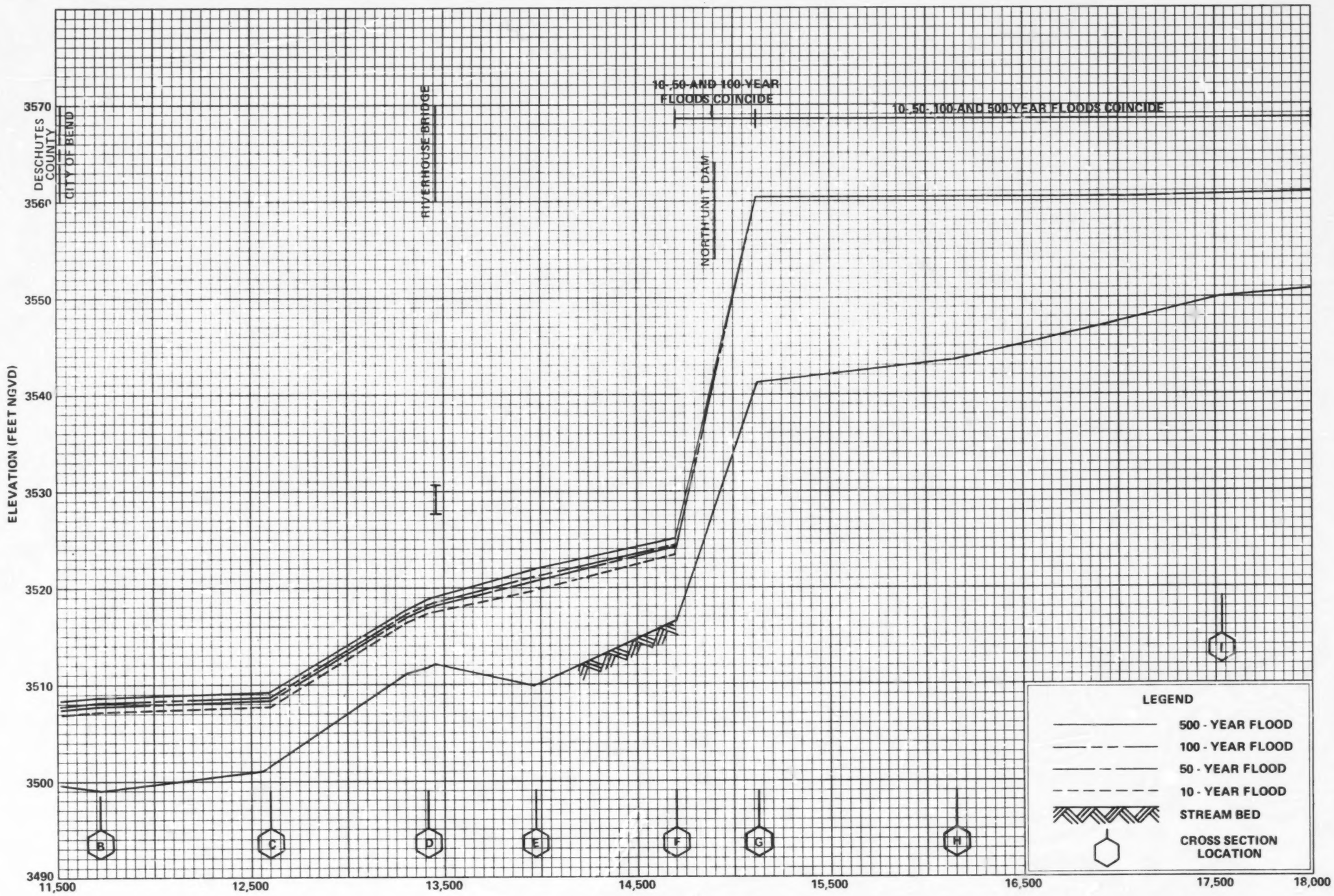

FLOOD PROFILES

DESCHUTES RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF BEND, OR
(DESCHUTES CO.)

C2P

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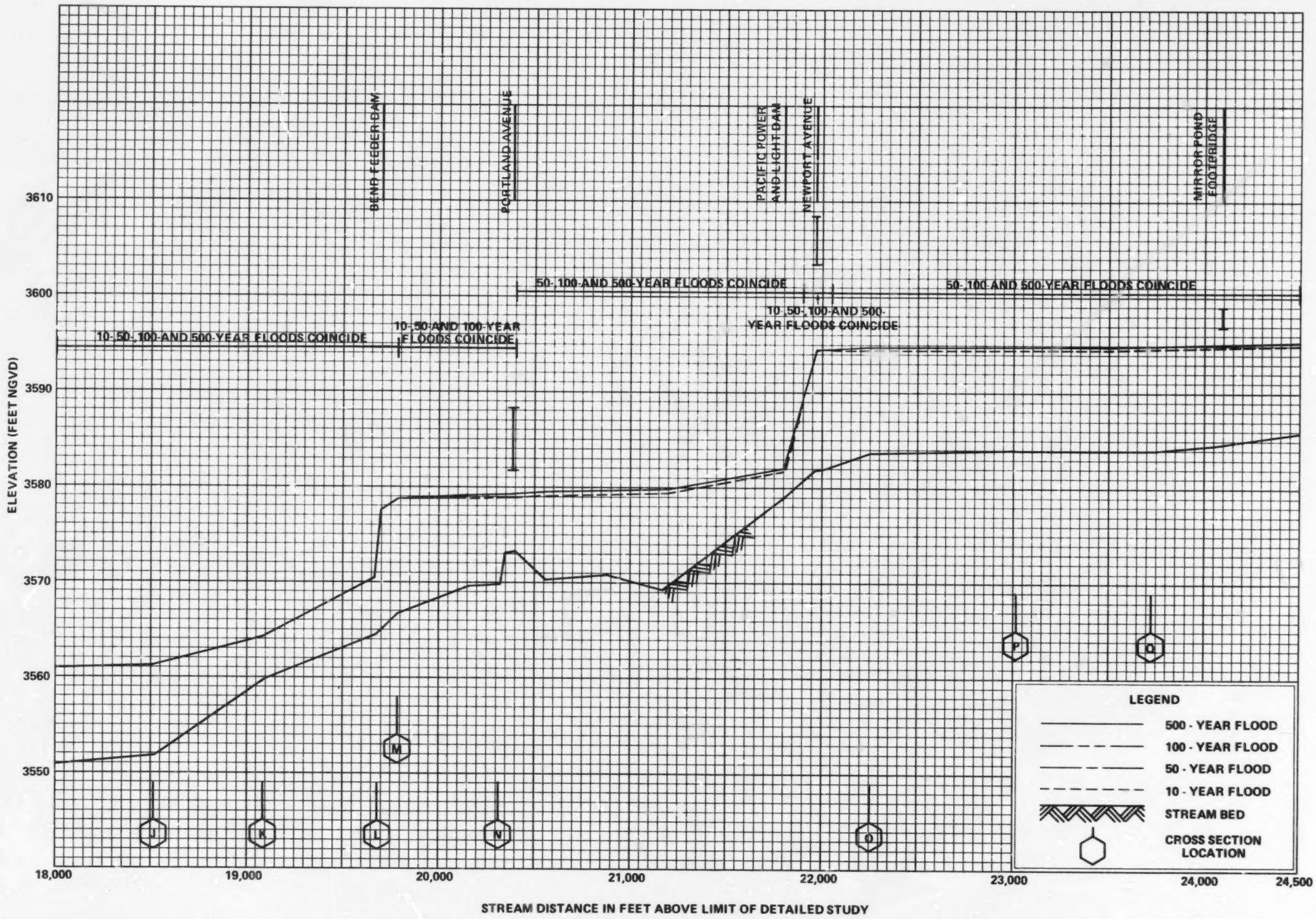

FLOOD PROFILES

DESCHUTES RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF BEND, OR
(DESCHUTES CO.)

03P

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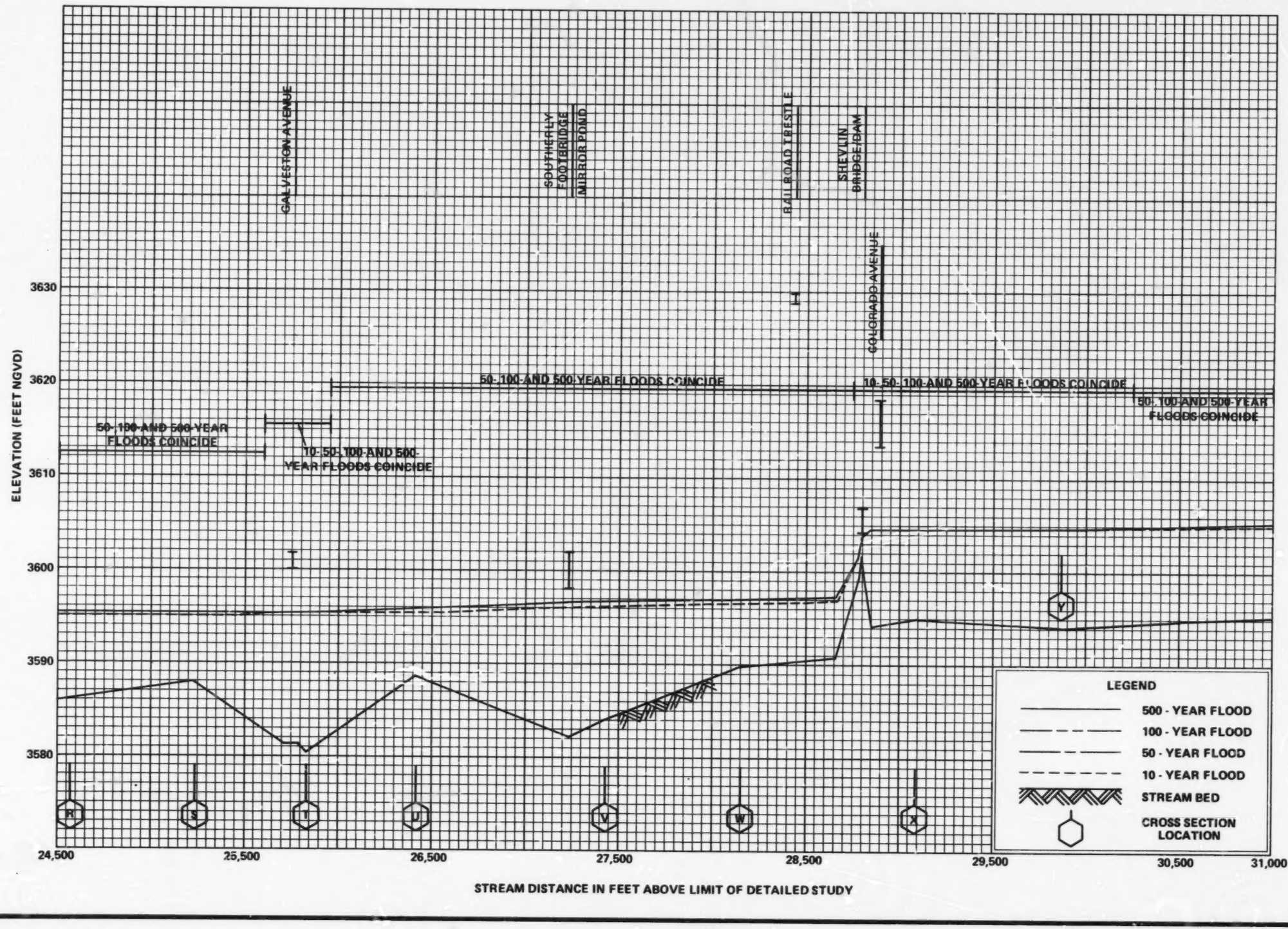

FLOOD PROFILES

DESCHUTES RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF BEND, OR
(DESCHUTES CO.)

04P

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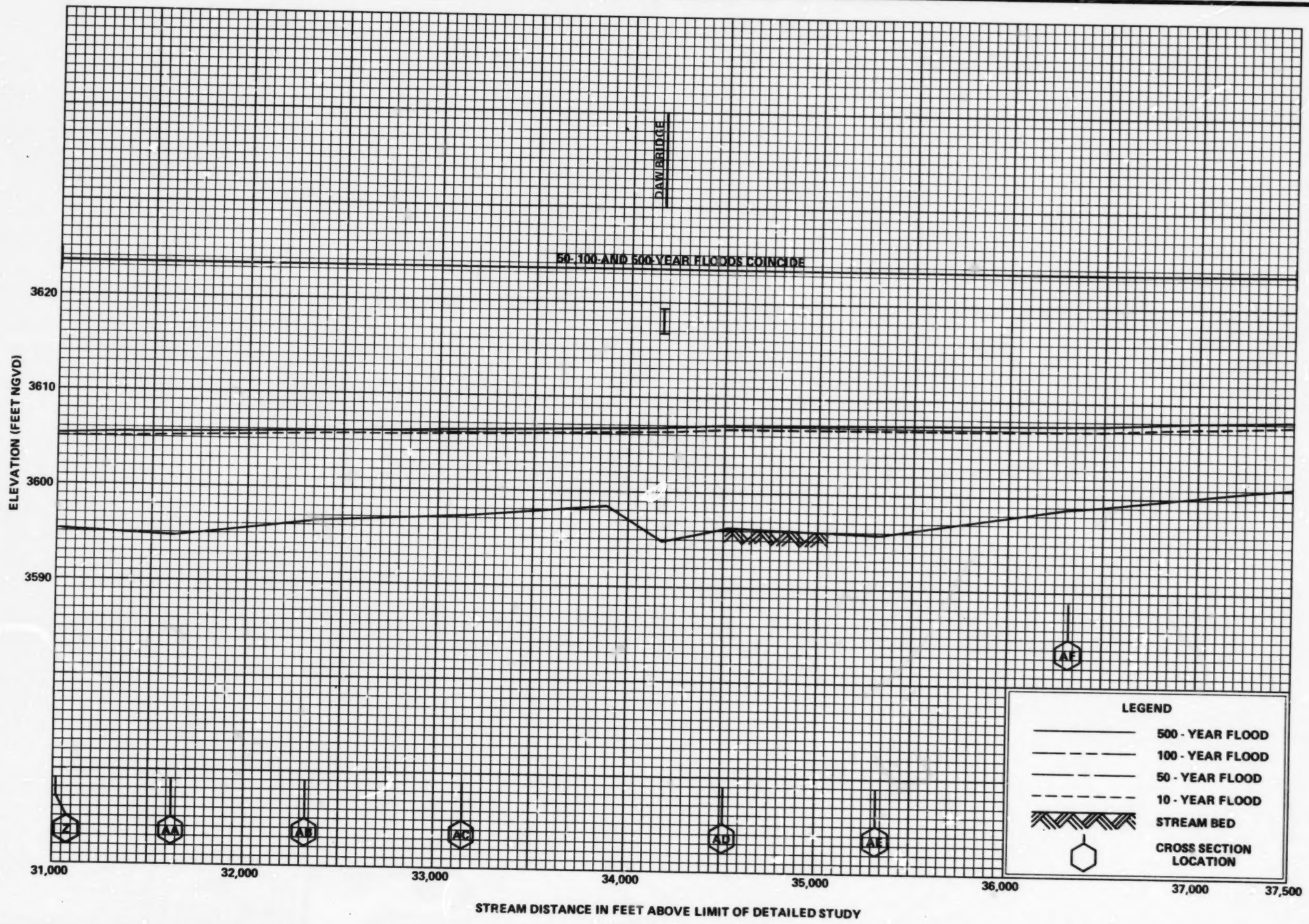

FLOOD PROFILES

DESCHUTES RIVER

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CITY OF BEND, OR
(DESCHUTES CO.)

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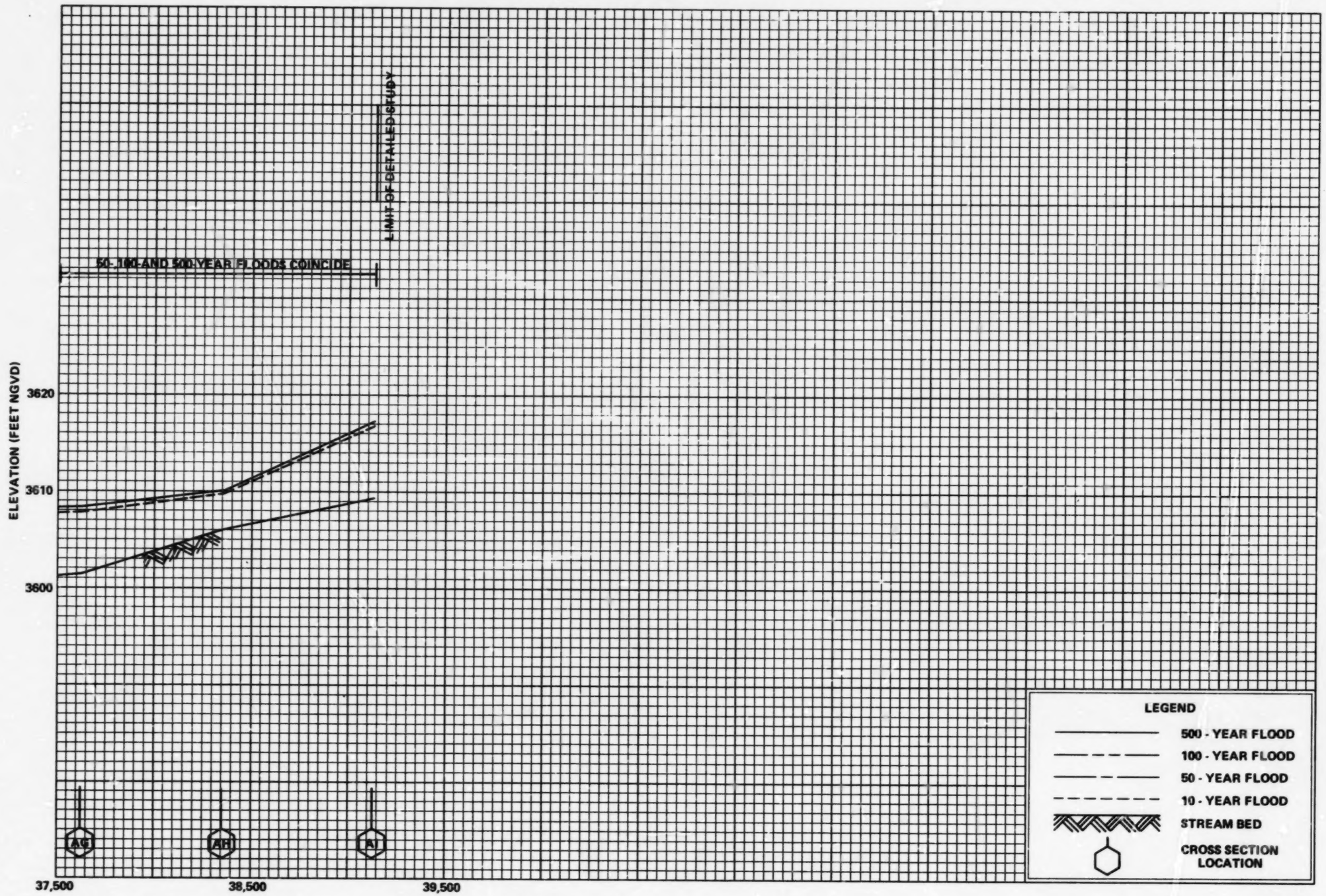

FLOOD PROFILES

DESCHUTES RIVER

FEDERAL EMERGENCY MANAGEMENT AGENCY

CITY OF BEND, OR
(DESCHUTES CO.)

06P

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Exhibit 3 - Elevation Reference Marks

REFERENCE MARK	FIRM PANEL	ELEVATION (FEET NGVD)	DESCRIPTION OF LOCATION
RM1	0005	3,530.81	COE brass disk set in concrete on northeastern corner of bridge just south of Riverhouse Motel.
RM2	0005	3,534.13	PK nail set 5 feet east of western edge of pavement southwest across U.S. Highway 97 from Izzy's Pizza, white "+" painted on pavement, witness post westerly 9.5 feet, 2.6 feet west of fogline, approximately 80 feet south of southerly entrance to Riverhouse Motel, set R.P. nail and aluminum flasher in 16 inch ponderosa pine S 74°W 35.10 feet (COE).
RM3	0005	3,586.68	Brass disk in concrete at northwestern corner of Portland Avenue bridge over Deschutes River (COE).
RM4	0005	3,595.17	Pacific Power & Light Company brass disk, 1926, on eastern wingwall of dam, 1 foot north of top of stairway by powerhouse.
RM5	0005	3,608.98	COE brass disk in southeastern corner of Newport Avenue bridge, in sidewalk.
RM6	0005	3,596.48	Brass disk in rock in Drake Park between rest-rooms and river, by flagpole.
RM7	0005	3,601.93	Brass disk in sidewalk, left bank of river, on downstream side of Galveston Avenue bridge over Deschutes River, 20 feet west of end.

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Exhibit 3 - Elevation Reference Marks (Cont'd)

REFERENCE MARK	FIRM PANEL	ELEVATION (FEET NGVD)	DESCRIPTION OF LOCATION
RM8	0005	3,604.21	COE brass disk in concrete footing of trestle, right bank, west side of asphalt bike path, downstream from Colorado Avenue bridge.
RM9	0005	3,753.35	U.S. Coast and Geodetic Survey brass disk, 1942, in 7- by 10-foot boulder, east of Century Drive, at entrance to Mt. Bachelor at Village, S 62°E 43'. from SHRW monument.